LIFE HISTORY OF THELIA BIMACULATA FAB. (MEMBRACIDÆ).

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(Contribution from the Entomological Laboratory of Cornell University.)

Thelia bimaculata Fab., is one of the most common and widely distributed of the species of Membracidæ in eastern United States and is abundant on locust (*Robinia pseudacacia* L.) in the vicinity of Ithaca, N. Y., where the following study has been made. The life history of this insect has not hitherto been described and the only reference in literature to the immature form seems to be the short description and the excellent figure of the last nymphal stage by Matausch* in 1912. Although both adults and nymphs may be collected in large numbers throughout the summer, the efforts of several years of rather extensive field work on the local forms of the family failed to show any records of oviposition or traces of the eggs until it was noticed that early in the spring the nymphs appeared most abundant near the bases of the trees and seemed to be migrating upward on the trunk, which led to the natural conclusion that the eggs were laid near the ground. This surmise proved to be correct and upon removing the dead leaves and humus from around the bases of the trees, great numbers of nymphs with their attendants were exposed, and the bark, a few inches under the forest litter and just above the roots, was found to be punctured with egg-slits and full of eggs and emerging nymphs. This location for the egg-punctures is rather peculiar, since most of the species of Membracidæ common to this locality lay their eggs in the buds or in the younger twigs near the end of the branches.† After the eggs were discovered and the egg-laying habits observed, no difficulty was experienced in rearing the insects and in securing the rest of the life-history data.

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* Matausch, Ignaz Bull. American Museum Natural Hist. 1912. Vol. XXXI: 26, 333. Pl. 29, Fig. 7.

† Cf. Hodgkiss, H. E. The Apple and Pear Membracids. Geneva Agr. Exp. Sta. Tech. Bull. No. 17. 1910.
Riley, C. V. Proc. Ent. Soc. Wash. 1893. Vol. III: 88–92 p.
Marlatt, C. L. Insect Life. 1894. Vol. VII: 8–14 p.
Matausch, I. Observations on the Life History of Enchenopa binotata Say. Journ. N. Y. Ent. Soc. March, 1912. Vol. XX: No. 1. 58–67 p.

General Description.

This species of Membracidæ is one of the largest representatives of the family found in New York state. The male was originally described by Fabricius in 1794 and no doubt received its specific name from the gaudy yellow fascia on the thorax. The female is quite different in color from the male, being of a sober uniform gray with occasional irregular brownish markings. *Thelia bimaculata* is the type of Amyot and Serville's old genus *Thelia* (1843) and is one of the few remaining species now left in that genus.

The species may be at once recognized by the porrect pronotal horn, the longitudinal ridges of the prothorax, the sharp posterior process and the yellow stripes of the male.

Habits.

Of all the insects which inhabit the locust none are more interesting or more easily observed than this large and handsome species of membracid. Locally they may be found in remarkable numbers from early spring until late autumn, and with their nymphs and constantly attending ants provide a most profitable source of study. They seem to prefer the smaller trees and are most abundant in rather open growths where the trees are young and not over twenty feet in height, and here they choose the lower branches and the trunk for their resting places. They are seldom found more than fifteen feet above the ground. Like most membracids they enjoy the sun and the most favorable collecting places are the trees in the open fields, along the roadsides, and at the edges of timber. They are seldom, if ever, seen in shady woods. The adults have the interesting habit of resting on the larger branches and on the trunk in rows of from twenty to forty individuals, ranged so close together that their bodies are almost touching, and almost invariably with the heads pointing towards the base of the branch, or pointing downward if they are on the trunk. Whether this characteristic attitude is assumed in order to increase their resemblance to the thorns and irregularities of growth of their host, would be a matter of conjecture. An idea of the number of individuals which may thus be found may be given by the fact that one field note (July 22, 1911) records the taking of 280 adults and over 200 nymphs at one time from one small tree.

The species is not active, although the insects fly well for short distances with a distinct buzzing flight, and they may usually be picked up with the fingers without difficulty. The males are more active than the females and more easily disturbed. Migration is evidently slow, as it often happens that one tree may be covered with individuals while another in close proximity is unmolested. In this locality, under ordinary conditions, both sexes appear in nearly equal numbers until about the middle of August, after which time the males become scarcer and by the first of October have practically disappeared, although the females remain abundant until late in November. Females have been collected, in fact, some time after the first few snows have fallen, but there is no evidence to show that any of the adults winter over.

The nymphs are usually found on the trunk near the ground, tightly flattened against the tree in the crevices of the bark, a position which makes their protective resemblance truly remarkable, and where the gray color and spiny dorsum is conducive to a most effective concealment. The larger individuals migrate upward and when seen on the branches are found pressed closely to the bark in the crotch of a twig or the axil of a leaf, where they tend to escape any but the most careful search. They are, however, attended by ants in large numbers, and these vigilant attendants betray to the collector of the nymphs the object of his search. The anal tubes of the immature insects are capable of great evagination and from these tubes issues in bubbles the liquid which the ants seek. This liquid appears to be secreted more abundantly when the ant strokes the nymph with its antennæ. When picked up in the fingers the nymphs at once eject some of this fluid, sometimes in considerable quantities. The ants attend the adults as well as the nymphs but only the nymphal forms have been observed to give off liquid in the manner described. The ants do not hesitate to protect their charges, and bite viciously the fingers of the collector who seeks to remove the nymphs from the tree.

Mating and Oviposition.

Under natural seasonal conditions mating begins in the field about the first week in July. The position assumed in this process is the one not unusual in Hemiptera, with the caudal extremities together and the heads in opposite directions. The

individuals are very sluggish at this time and seldom move unless disturbed. The time taken in the field for the process is generally about twenty minutes, but one pair in the laboratory remained *in cop* for almost an hour. Mating continues throughout the summer, the largest number of cases being noted during the last week in August. The last date on which this process has been observed in the field was November 6th.

In oviposition the female descends to the base of the tree, with the head pointing downward, and makes a narrow longitudinal slit about seven millimeters long in which the eggs are deposited. In very young stems the egg-slit sometimes pierces the wood but in most cases the ovipositor is deflected on striking the wood and slips to one side, the eggs being laid in the cambium between the bark and xylem. The slit is very narrow and hardly noticeable but the tips of the eggs may be seen protruding very slightly out of the bark when the process is completed (Fig. 3.) The eggs are about 2½ mm. long, white and club-shaped (Fig. 1). They are laid in a palmate formation (Fig. 2) recalling the egg-mass of *Stictocephala inermis* Fab.,* but much larger. The bases of the eggs are about 5 mm. apart and the apices compressed closely together. The number of eggs varies from three to six in a slit, the latter number being most common. The process occupies about forty minutes, after which the insect usually moves upward and slightly around the stem and repeats the process. One female has been known to make three such slits in succession, but as egg-laying is usually observed in the late afternoon it is difficult to keep field records on this score and the average number of egg-masses laid by one female at one time may be larger. Dissection shows the average number of eggs in the abdomen of the female to be twenty-eight.

Emergence and Development of Nymphs.

The first numphs begin to appear in late May and early June. Field records made on May 30, 1911, June 1, 1912, June 2, 1913, and June 1, 1914, show that the early stages were collected on these dates. About two days before hatching, the tips of the eggs begin to crack and just before the nymphs emerge, break open at the top and usually split some distance down the side.

*Agr. Exp. Sta. Tech. Bull. 17. Geneva, 1910. Pl. 2, Fig. 5.

There are five instars and each may be easily recognized. In the first (Fig. 4) the insect is almost white and the dorsum is armed with branched spines as in the case of the nymphs of the subfamily *Ceresini*. The beak is very long, reaching almost to the tip of the abdomen. In the second instar (Fig. 5) the nymph is dark colored, the thoracic spines have almost disappeared, the abdominal spines are much shorter and three-branched and the beak still very long. The third instar (Fig. 6) shows no thoracic spines but a swelling which precedes the pronotal horn, the meso- and metathoracic segments are slightly lengthened at their lateral margins and the abdominal spines are simple and not branched. In the fourth instar (Fig. 7) the pronotal swelling has become lengthened and porrect and the wing-pads are apparent, while the abdomen is marked with dark spots and the beak is shorter. The fifth and last instar (Fig. 8) presents a greatly developed pronotum which now covers the mesonotum, the wing-pads are fully developed and the legs are characteristically mottled with brown.

The time occupied in this process appears to be subject to some variation but whether this is due to seasonal or weather conditions it has not been possible to determine. It has been noticed that the nymphs which appear in the early summer require a slightly shorter time between the periods of molting than those which emerge in the fall. It has also been observed that in some cases the males appear to require a longer time in each nymphal stage than do the females. The first molt usually occurs about a week after hatching; the second five days later; the third instar lasts six days; the fourth instar six days, and the last, which is subject to the most variation, from eight to fifteen days. Thus the total period from egg to adult is approximately one month.

Ecdysis.

The splitting of the integument first appears on the dorsal part of the head. It then continues down the median dorsal line but seldom extends farther than the sixth abdominal segment. The head is released slowly but the thorax quickly follows and the integument sometimes breaks around the coxæ and femora leaving parts of the old skin attached to the legs for some time after the ecdysis is completed. In fact, this insect often leaves an imperfect exuviæ, and forms are commonly found with rem-

nants of the old integument still clinging to the legs and abdomen. The abdomen is removed slowly, here again, especially in the case of the female, small pieces of old skin sometimes remaining attached to the caudal extremity to be sluffed off later. The process is a comparatively rapid one, usually occupying about twelve minutes, while in one case observed in the laboratory (in the last molt) the time from the first splitting of the skin over the head to the complete emergence of the insect lasted only five minutes.

The recently emerged adults are almost white, the abdomen gray or greenish, and the whole body very soft. The thorax hardens rapidly and the normal color is completely apparent at the end of six hours. At first the colors are quite brilliant but become duller in a few days. The newly molted adults are very active and fly in a surprisingly short time but during the first few hours of their adult life the pronotal horn is likely to be injured on account of its soft condition, and if crushed or twisted will harden permanently in that position.

The old nymphal skins do not remain attached to the host but drop to the ground as soon as the ecdysis is complete. Consequently the cast skins are not seen on the trees as they are in the case of most of our other forms of Membracidæ.

Feeding.

Although careful field notes have been kept on this species for several years, and a very large number of individuals have been observed under natural conditions, surprisingly few actual instances of feeding have been noted. When recorded, it has always been in the early morning, and the insects have been, not on the more succulent twigs as might be expected, but on the second or third year's growth, with their beaks in the crevices of the bark. In the laboratory the nymphs fed on the young stems but the feeding periods were very short and they seldom moved about on the plant. No records were made of the nymphs feeding in the field. It may be noted that both while feeding and while molting the nymphs are constantly attended by swarms of ants which seem in no way to disturb the membracids and it has even been suggested by Miss Branch* that the ants are necessary factors in the life of an individual

* Branch, Hazel E. The Kansas University Bulletin. July, 1913. Vol. VIII: No. 3., p. 84.

membracid. The experience of that author, however, in rearing the nymphs of *Entylia sinuata*, in which species the molting was not successfully accomplished in the laboratory without the presence of ants, has not been experienced in the rearing of *Thelia bimaculata*, since this latter insect has molted repeatedly while in the cages in the insectary without the attendance of ants. The feeding of this membracid, likewise, has not seemed to be affected in the least by the absence or presence of these usual attendants.

Hosts.

Robinia pseudacacia L. seems to be the only host supporting *Thelia bimaculata* in this locality. Specimens have never been taken on any other tree although in general collecting for Membracidæ practically all of the local flora has been examined. Likewise, no evidences of eggs or nymphs have ever been found except on this one host. Neither have specimens of this species been collected in the grass or weeds or by sweeping and it seems evident that the entire life cycle of the insect is spent on the locust. As has been stated, the migration of this form seems to be limited and the insects appear year after year in a given group of trees while others nearby are not infested.

Enemies.

Parasitism is common in the eggs but none of the parasites have been identified in the course of this study. Many eggs fail to mature and are found to be punctured and blackened. The bodies of both nymphs and adults, also, often contain larvæ—apparently hymenopterous—but none of these have thus far been successfully reared although several attempts have been made to work out this phase of the subject. Matausch has recorded parasitism in this species† which destroyed the sexual organs but was not able to rear the parasites.

The larger Asilids occasionally carry off a membracid and in one instance a toad was found at the foot of a tree busily engaged in trying to secure the nymphs. In this case the operation seemed to be fraught with some difficulties on account of the tenacity with which the membracids held to their host and on account of their sheltered position in the cracks of the bark,

† Matausch, Ignaz. The effects of parasitic castration in Membracidæ. Jour. N. Y. Ent. Soc., Sept., 1911. Vol. XIX: No. 3. 194-196 p.

and they would doubtless have escaped unnoticed had it not been for the movements of the large ants running briskly about them. Birds apparently avoid the insect. No case of their being eaten by birds has been observed in the field, and several handfuls thrown to birds in captivity were refused, although one or two individuals were picked up, only to be dropped again. Evidently the strong pronotal horn and the sharp posterior process (the latter being sharp and hard enough to pierce the skin if the adult insect is suddenly seized) and the hard prothorax are sufficient protection from bird enemies. The bodies of these insects are occasionally infested by a small red mite, and not infrequently a membracid is found in a spider's web.

Attendance By Ants.

The attendance by ants on various species of Membracidæ has often been recorded. Interesting notes have been published on this subject by Mrs. Rice[1], Miss Branch[2], Belt[3], Green[4], and Lamborn[5], and attention called to the fact by other authors. In the case of *Thelia bimaculata* this is a most noticeable and interesting feature of their life-history. The species of ants which have been found attending both nymphs and adults have been very kindly determined by Professor W. M. Wheeler as follows: *Formica obscuriventris* Mayr, *Formica exsectoides* Forel, *Camponotus pennsylvanicus* DeGeer, *Crematogaster lineolata* Say and *Prenolepis imparis* Say.

Economic Importance.

Thelia bimaculata can hardly be considered as an insect of economic importance in so far as any damage to the tree caused by its presence is concerned. The amount of sap consumed is apparently very small and the method of egg-laying has practically no injurious effect on the host. The fact that the egg-slits are very narrow and placed longitudinally, makes it possible for the bark to quickly heal over the wound and the scars have

[1]Rice, Mrs. M. E. Insect Life. 1893. Vol. V: No. 4. 243–245 p.

[2]Branch, Hazel E. Morphology and Biology of the Membracidæ of Kansas. Kans. Univ. Bull. 1913. Vol. VIII: No. 3. p. 84.

[3]Belt, T. Honey exuding Membracidæ attended by ants. Naturalist in Nicaragua. 1874.

[4]Green, E. E. Note on the attractive properties of certain larval Hemiptera. Ent. Month. Mag. Aug. 1900. Vol. XXXVII: p. 185.

[5]Lamborn, W. A. Ants and Membracidæ. Trans. Lond. Ent. Soc. 1913. 494–498. p.

usually disappeared after the second season. No trace has been found of other insects or of fungus in the openings thus made, and since the ovipositor of the insect seldom penetrates the wood there is no trace of the incision below the bark. A careful comparison of trees in the field has led to the conclusion that those on which the membracids were numerous were in no way less sturdy than those on which no membracids were found.

Technical Descriptions.

Egg:

Measurements: Average length 2.6 mm.; average greatest width .6 mm.

Club-shaped. Smooth, without sculpturing. Translucent white with pointed end opaque white. Neck gradually acute. Chorion vitreous. Cap comparatively large, somewhat wrinkled. Micropylar apparatus opaque and white.

First instar:

Measurements: Length 1.8 mm.; maximum width .2 mm.

White, with brown head and brown dorsal spots; dorsal surface decorated with prominent bristles.

Head broad, flat, brown, covered with long bristles; constriction between head and thorax deep; eyes prominent, centers blood-red; antennæ colorless, well developed; clypeus white; beak white and extending almost to tip of abdomen; ferruginous maxillary and mandibular setæ visible. Prothorax prominent, brown, tuft of three paired bristles on median dorsal line, one pair of very fine bristles anterior to this tuft and a single bristle on each side below it. Mesothorax white with brown lateral patch on each side near dorsum, one heavy branched bristle on each side median dorsal line with fine lateral bristle below it. Metathorax white, four fine unbranched dorsal bristles. Abdomen with eight visible segments, brown above, white below, fifth and sixth segments white throughout, seventh and eighth segments brown above and white below, each of first six abdominal segments bearing above a pair of heavy branched spines suddenly acuminate in a fine bristle and two rows of fine lateral hairs, seventh and eighth segments with a pair of fine unbranched bristles on each side dorsal line, underside of abdomen white and sparsely pilose, anal tube protruding. Legs and feet entirely white, femora and tibiæ hairy. The above description from a specimen killed and described immediately on its emergence from the egg.

Second instar:

Measurements: Length 2–2.8 mm.; maximum width 1 mm.

Entirely light chocolate brown except undersurface of abdomen which is white; body very finely punctate with white.

Head finely pilose; dorso-cephalic part produced into two tuberosities; beak heavy and extending almost to extremity of abdomen.

Prothorax brown with two pairs of short blunt bristles. Meso- and metathorax each uniform brown with one pair of obsolete bristles on median dorsal line. Abdomen brown, posterior margins of segments darker; eight segments distinct, first six pairs bearing double row of blunt spines at dorsal line, each spine with short lateral bristles and ending in a fine hair, last two segments faintly bristled; anal tube prominent. Legs brown, somewhat lighter at joints.

Third instar:

Measurements: Length 3–5 mm.; maximum width 2–2.5 mm.

Gray-brown mottled with dark brown; undersurface of abdomen lighter. Body wider and flatter in proportion than in preceding instars; widest in abdominal region. Pronotal horn beginning to appear on prothorax and lateral margins of meso- and metathorax beginning to lengthen to form wing-pads.

Head wide, frontal tubercles prominent, front of head dark in color; eyes brown, facets distinct; ocelli visible; clypeus set off by distinct suture; beak extending to a point half-way between hind coxæ and apex of abdomen. Prothorax with prominent tuberosity on median dorsal line; entire dorsal surface of prothorax swollen. Mesothorax and metathorax almost smooth above; lateral margins of each of these segments extended in blunt points. Each abdominal segment bearing double row of short, sharp spines above; two parallel rows of dark spots on each side of abdomen in about the position in which the lateral hairs appeared in the first instar; anal tube prominent and black. Legs mottled brown; femora almost black; tibiæ lighter at extremities; tarsi flavous.

Fourth instar:

Measurements: Length 5–7.5 mm.; maximum width 2.5–3 mm.

Body robust; abdomen heavy; color light mottled gray. Pronotal process becoming porrect; prothorax overlapping mesothorax. Wing-pads well developed.

Head decidedly prone; frontal tuberosities pointing directly forward; eyes light brown; ocelli prominent; clypeus well defined; beak reaching just beyond posterior coxæ. Prothorax well developed; anterior process becoming porrect; posterior margin of pronotum beginning to overlap mesonotum. Mesothorax and metathorax almost smooth above; wing-pads well formed and prominent, covering one-third of second abdominal segment at lateral margin. Abdomen very light in color with longitudinal brown fascia above, almost white below; spiracles very distinct; anal tube darker than the rest of the abdomen and often much distended; first two abdominal segments almost smooth above, next five bearing short, thickened spines. Legs and feet mottled brown, sparingly spined and pilose; femora hairy and club-shaped; tibiæ somewhat flattened; tarsi comparatively large; claws heavy and strong.

Fifth instar:

Measurements: Length 8–10 mm.; maximum width 3.5–5 mm.

Body robust; mottled gray; anterior pronotal process porrect; pronotum entirely covering mesonotum dorsally; wing-pads fully developed, first and second pads extending about equidistant posteriorly; legs mottled.

Head much deflexed; frontal tuberosities small; eyes brown; ocelli white; clypeus distinct. Prothorax well developed and strongly chitenized; anterior process projecting far forward, cylindrical; mesothorax and metathorax distinct; wing-pads long, wings sometimes faintly visible through the pads. Abdomen greatly swollen; double row of blunt spines down dorsal line, smaller anteriorly and increasing in size toward the posterior end; nine segments distinctly visible; undersurface of abdomen greenish-white, in female sometimes showing impression of ovipositor. Legs strongly marked with patches of gray-brown; femora and tibiæ pilose; tarsi lighter in color; claws ferruginous.

Adult—Female:

Measurements: Length 11 mm.; length including horn 14 mm.; width between humeral angles 5.5 mm.

Gray with indistinct darker irregular markings; porrect cylindrical horn, slightly flattened and somewhat darker in color at the tip; tegmina hyaline, apex fuscous, almost reaching extremity of dorsal process.

Head including eyes twice as broad as long, grayish-yellow mottled with ferruginous and brown; margins of loræ strongly sinuate; clypeus pilose; eyes dark brown; ocelli white, nearer to each other than to the eyes and situated on a line drawn through center of eyes; beak extending to posterior coxæ; head very sparingly punctate and sparsely pilose. Thorax gray, deeply and densely punctate; median percurrent brown line sharpened into a ridge on extremity of horn and at apex of posterior process; sides of prothorax roughly and irregularly carinate; horn porrect and greatly variable in length, cylindrical except at extreme tip where it is flattened laterally; posterior process heavy, tectiform, gradually acute, almost straight, very slightly decurved and extending just beyond apex of tegmina. Tegmina hyaline, apex fuscous, base and costal region lightly punctate; under-wings hyaline, two-thirds as long as tegmina. Under surface of body gray-brown, pubescent. Legs uniform yellow brown; femora thick and smooth; tibiæ and tarsi densely pilose.

Male:

Differs from female in size and markings. Smaller, body somewhat less robust; porrect horn usually shorter and tending to curve; tegmina equalling apex of posterior process. Color deep chocolate brown; porrect horn almost black; apex of posterior process becoming cinnamon brown; a wide, brilliant, lemon-yellow longitudinal stripe on each side of prothorax, extending from margin half-way to median dorsal line, also small patches of yellow on metopidium; head yellow with brown patches. Undersurface of abdomen darker than in female.

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EXPLANATION OF PLATE IX.

Fig. 1. Egg.
Fig. 2. Egg-mass showing arrangement (Inside of bark).
Fig. 3. Egg-slit showing tips of eggs (Outside of bark).
Fig. 4. First instar.
Fig. 5. Second instar.
Fig. 6. Third instar.
Fig. 7. Fourth instar.
Fig. 8. Fifth instar.
Fig. 9. Adult female.
Fig. 10. Adult male.

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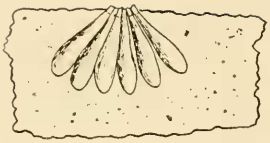

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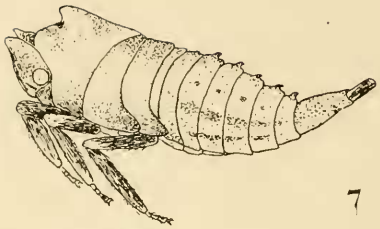

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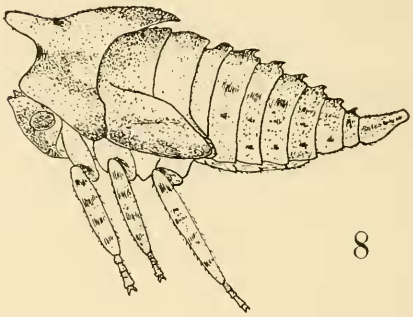

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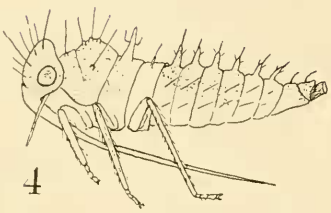

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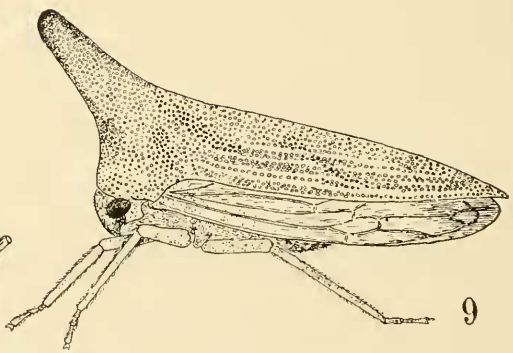

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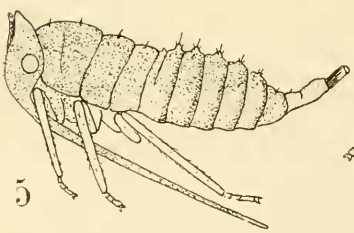

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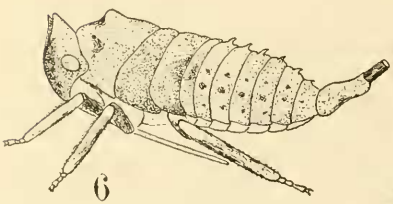

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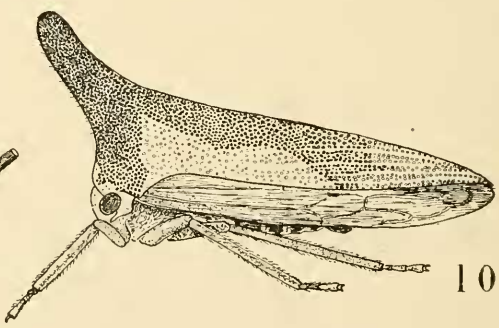

10

W. D Funkhouser.